VICTOREEN

Instruction Manual

Ion Chamber Survey Meter

Model RPO-50

Part No. 181001

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WARRANTY

The equipment described in this manual is intended to be used for the detection and measurement of ionizing radiation. It should be used only by persons who have been trained in the proper interpretation of its readings and the appropriate safety procedures to be followed in the presence of radiation.

Although the equipment described in this manual is designed and manufactured in compliance with all applicable safety standards, certain hazards are inherent in the use of electronic and radiometric equipment.

In addition, the nuclear radiation calibration (when applicable) for each instrument is warranted to be within its specified accuracy at the time of shipment. If an error in this initial calibration is discovered, the instrument will be recalibrated at no charge, provided it is returned as described above. This does not apply to any calibration deviation that may result from normal use.

There are no warranties, expressed or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond that stated here. This expressed warranty excludes coverage of, and does not provide relief for, incidental or consequential damages of any kind or nature, including, but not limited to loss of use, loss of sales or inconvenience. This exclusive remedy of the purchaser is limited to repair, recalibration, or replacement of the instrument at VICTOREEN's option.

This warranty does not apply if the product, as determined by VICTOREEN, has been damaged by accident or misuse, or as a result of service or modification by other than an authorized VICTOREEN service facility. This warranty is void if the unit is subjected to temperatures above 55^{o}C unless otherwise indicated.

INSPECTION AND MATERIAL RETURN INSTRUCTIONS

Instruments should be examined and tested as soon as received by the purchaser. Claims for damage, if any, should be filed at once with the carrier. Any material returned for repair must be accompanied by a valid customer purchaser order, identifying the work to be done. A Material Return Form is provided at the back of this manual. Send the completed form with items returned for repair to:

VICTOREEN, Inc.
6000 Cochran Rd.
Cleveland, Ohio 44139

Phone: (216) 248-9300
Fax: (216) 248-9301

Material valued at $200.00 or more and/or weighing more than twenty pounds should be shipped the best way prepaid and fully insured.

VICTOREEN suggests that any instrument weighing over twenty pounds be wrapped in heavy craft paper and packed in a double corrugated carton or wooden box. Protect the instrument on all sides with at least three inches of excelsior or similar padding. Mark the case plainly with suitable caution warnings to insure careful handling.

CAUTION

The equipment described in this manual is intended to be used for the detection and measurement of ionizing radiation. It should be used only by persons who have been trained in the proper interpretation of its readings and the appropriate safety procedures to be followed in the presence of radiation.

Although the equipment described in this manual is designed and manufactured in compliance with all applicable safety standards, certain hazards are inherent in the use of electronic and radiometric equipment.

READ YOUR INSTRUCTION MANUAL

Table of Contents

Page

Section 1 - Introduction 1-1
1.1 Product Description 1-1
1.2 Specifications 1-3
1.3 Energy Response 1-5
1.4 Altitude Corrections 1-5

Section 2 - Receiving / Storage 2-1
2.1 Receiving Inspection 2-1
2.2 Storage 2-1
2.3 Battery Installation / Replacement 2-1

Section 3 - Operation 3-1
3.1 Description of the Readout 3-1
3.2 Description of the External Controls 3-1
3.2.1 Function Switch 3-1
OFF Position
BATT Position
ZERO position
5000 mR/Hr Position
500 mR/Hr Position
50 mR/Hr Position
5 mR/Hr Position
3.2.2 Zero Knob 3-2
3.2.3 Light Switch 3-2
3.3 Beta Shield 3-2
3.4 Operating the Instrument 3-2

Section 4 - Theory of Operation 4-1
4.1 General 4-1
4.2 Functional 4-1
4.3 Circuit description 4-1

Section 5 - Calibration 5-1
5.1 Tamper Evident Adhesive Cover 5-1
5.1.1 Factory Calibration Points 5-1
5.2 Calibration Potentiometers 5-1

Section 6 - Maintenance / Troubleshooting 6-1
6.1 Preventive Maintenance 6-1
6.1.1 Batteries 6-1
6.1.2 Desiccant 6-1
6.2 Corrective Maintenance 6-2
6.2.1 Precautions 6-2
6.2.2 Disassembly 6-2
6.2.2.1 External End Window Replacement 6-2
6.2.2.2 Internal End Window Replacement 6-2
6.2.2.3 Light Intensity Adjustment 6-2
6.2.2.4 Lithium Battery Replacement 6-2
6.2.2.5 Circuit Troubleshooting 6-3
6.2.3 Reassembly 6-4

Appendix A - Customer Replaceable Parts 7-1

Appendix B - RPO-50 Technical Paper 8-1

List of Figures

		Page
Figure 1-1.	Model RPO-50 General View	1-2
Figure 1-2.	Energy Response	1-6

List of Tables

		Page
Table 1-1.	Altitude Corrections (Feet)	1-7
Table 1-2.	Altitude Corrections (Meters)	1-8
Table 4-1.	Switch Position Truth Table	4-1
Table 4-2.	U8 and U9 Control Logic	4-2
Table 4-3.	Test Point Descriptions	4-2
Table 5-1.	Factory Calibration Points	5-1

Section 1 - Introduction

1.1 Product Description

VICTOREEN Model RPO-50 is a portable, battery operated general purpose ion chamber survey meter. The design combines surface mount analog circuit technology, advanced "front end" FET sensitivity, and rugged mechanical features into an easy to use instrument. See Figure 1-1 for a general view.

The Model RPO-50 is housed in a heavy duty aluminum case with an ergonomically designed cast aluminum handle.

Measurement results are displayed on a 200 μA, high torque, taut band, back lit analog meter. The display includes a five decade scale and a battery OK region.

The following controls are available on the instrument:

A 7 position rotary Function Switch - which includes the OFF position, a BATTERY check position, a ZERO position, and 4 ranges; 5, 50, 500, and 5000 mR/Hr.

A 3 position display "LIGHT" switch - which includes an "OFF" position, "ON" position, and a spring return "MOMENTARY" on position.

A guarded ZERO adjustment knob - which is used to adjust zero on the instrument for each range.

Four 9 Volt alkaline batteries are mounted in rugged battery holders on their own circuit board inside the case. The battery lifetime is greater than 3000 hours. The manual battery check verifies that sufficient voltage is available to operate the instrument. The ion chamber is biased at -21 volts by 7 lithium batteries soldered into the main printed circuit board with a lifetime of greater than 10 years.

The ion chamber is 21.3 in^3 (349 cm^3) in volume which provides for excellent minimum detectability and stability for X-rays and gamma rays. The ion chamber thin end window, which is 3.25 inches (8.255 cm) in diameter, is positioned very close to the external instrument thin end window. The instrument's rubber feet have the lowest possible profile. All of these features are designed for the best minimum detectability and sensitivity for beta rays. The beta shield is 493 mg/cm^2, has a positive locking system for the open and closed positions, and is very easy to move.

The desiccant is located inside the housing in a plastic container and indicates, by its color, whether it is wet (pink or clear) or dry (blue or dark blue). The container has a lid for ease of desiccant replacement and / or drying. The desiccant can be restored by heating overnight at 50°C. The ion chamber is vented through the desiccant system by a sealed plastic tube.

The instrument features 4 easily accessible calibration potentiometers, one for each range. A tamper evident calibration adhesive tag covers the 4 calibration potentiometers.

There are no open holes in the case and gaskets are incorporated into the mating surfaces of all external parts, thus the instrument is sealed and resistant to dirt, moisture, contamination, and radioactive gas infusion.

Other than the controls, there are no moving parts, such as magnetic reed switches or mechanical arms. This assures mechanical ruggedness and the highest reliability available.

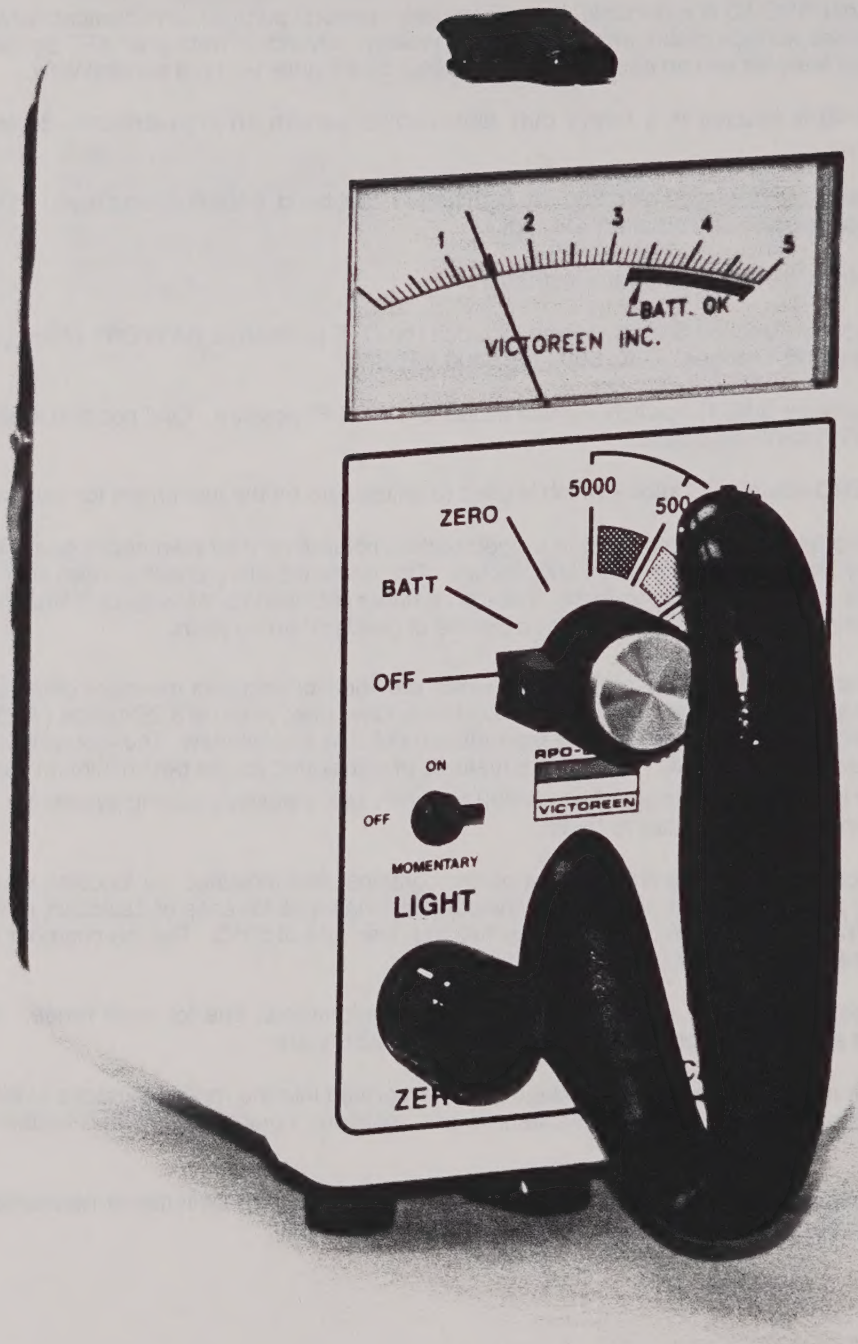

Figure 1-1. Model RPO-50 General View

1.2 Specifications

Radiation Detected:	Beta, Gamma, X-ray
Operating Range:	0 to 5000 mR/Hr in 4 linear ranges, 5 mR/Hr, 50 mR/Hr, 500 mR/Hr, and 5000 mR/Hr
Overall Accuracy:	± 10%
Response Time:	2.5 seconds (10 - 90%)
Detector:	
Type:	Ion Chamber
Pressurization Gas:	Air
Volume:	21.3 in^3 (349 cm^3)
Effective Diameter:	3.25 in. (8.255 cm)
Wall material:	0.0625" (0.16 cm) Phenolic
Wall thickness:	246 mg/cm^2
End Window material:	0.001 in. Mylar
End Window thickness:	3.5 mg/cm^2
Vented through desiccant system	
Case:	
End Window:	
Diameter:	3.25 in. (8.255 cm)
Material:	0.001 in. Mylar
Thickness:	3.5 mg/cm^2
Wall:	
Material:	0.0625" (0.16 cm) Aluminum
Thickness:	429 mg/cm^2
Construction:	Rugged aluminum wall Rugged aluminum top plate Cast aluminum handle Rubber feet on bottom and side of case Center of ion chamber clearly marked on three sides
Beta shield:	
Sliding motion	
Positive lock at both end positions	
Material:	0.125 in. (0.32 cm) Phenolic
Thickness:	493 mg/cm^2
Total attenuation:	
Wall:	675 mg/cm^2
End Window:	7.0 mg/cm^2 without beta shield 500 mg/cm^2 with beta shield
Desiccant System:	
Color:	Blue when dry, pink when wet
Material:	Silica Gel
Recovery:	Heating for at least 12 hours at 122°F (50°C)

Energy Dependence:

Photons: See graph, Figure 1-2 for photon response.

With the RPO-50 calibrated to 137Cs, slide closed with the side facing the source.

± 30% from 8 keV to 1.3 MeV with the slide open and facing the source

± 15% from 33 keV to 1.3 MeV with the slide closed and facing the source

± 15% from 55 keV to 1.3 MeV with the side facing the source

Beta Response (slide open, normalized to $^{90}Sr/^{90}Y$):

$^{90}Sr/^{90}Y$	100
^{36}Cl	54
^{99}Tc	34
^{14}C	6.6

Warm up Time: 15 Seconds transient when selecting 5mR/Hr range from ZERO position.

Display:

Decades:	5 linear, marked in 1/10 increments, with 5th increment bold
Battery:	OK region on Display
Scale Length:	3.5 in. (8.9 cm)
Lighting Modes:	Back lit with ON, OFF, MOMENTARY ON
Construction:	High torque, taut band, 200 µA full scale

Controls:

Function Switch:	7 Positions: OFF, BATT, ZERO, 5000, 500, 50, 5 mR/Hr
LIGHT Switch:	3 Positions: ON, OFF, MOMENTARY
ZERO Adjustment Knob:	Guarded Potentiometer
Calibration Potentiometers:	4; one for each range under a single adhesive calibration tag

Environment:

Temperature Range:	-40°C to 50°C
Humidity:	10% to 95% RH, non-condensing
Temperature Dependence:	Less than 0.015 mR / °C
Altitude:	See chart, Table 1-1

RF:

400 V/M 300 kHz to 35 MHz and 400 MHz: Less than ± 15%

Shock:

Drop from 1 meter: 5 times: Less than ± 15%

Vibration: 3.5 Gs on three orthogonal axis for 15 minutes over frequency range of 15-200 Hz

Geotropism: Within ±2% of full scale

Batteries:

Battery Check:	Manual
Lifetime:	Greater than 3000 hours
Voltage Dependence:	No change (%) at minimum voltage

Construction:

Weight:	3 lbs. 5 oz. (1.5 kg)
Dimensions (L x W x H):	8.0 x 4.2 x 7.75 in including handle; (20.3 x 10.7 x 19.7 cm)

Options:

Over the shoulder carrying strap

1.3 Energy Response

Figure 1-2 shows instrument photon energy response as a function of instrument orientation with respect to the radioactive source and beta shield position.

1.4 Altitude Corrections

The ion chamber is vented to the ambient atmosphere and its response to radiation varies with air density, which is altitude dependent. Air pressure and density decreases with increasing altitude. Tables 1-1 and 1-2 show instrument altitude corrections in feet and meters, respectively. These corrections should be applied to the readings whenever the instrument is used at altitudes other than that which it was calibrated. Normal barometric pressure changes at a given altitude will not significantly affect readings.

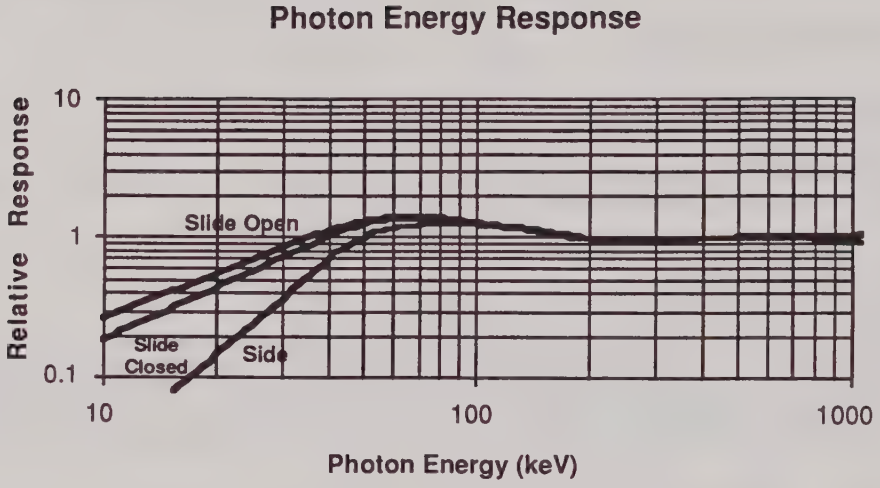

Figure 1-2. Energy Response

Table 1-1. Altitude Corrections (Feet)

Altitude at which measurement is made (feet above sea level)

Altitude at which Classic was calibrated (feet above sea level)	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9500	10000
0	1.00	1.02	1.03	1.05	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.25	1.27	1.30	1.32	1.35	1.38	1.41	1.44
500	0.98	1.00	1.02	1.03	1.05	1.07	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.23	1.25	1.28	1.30	1.33	1.36	1.38	1.41
1000	0.97	0.98	1.00	1.02	1.03	1.05	1.07	1.09	1.10	1.12	1.14	1.16	1.19	1.21	1.23	1.26	1.28	1.31	1.33	1.36	1.39
1500	0.95	0.97	0.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.24	1.26	1.29	1.31	1.34	1.37
2000	0.94	0.95	0.97	0.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.22	1.24	1.27	1.29	1.32	1.35
2500	0.92	0.94	0.95	0.97	0.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.20	1.22	1.25	1.27	1.30	1.33
3000	0.91	0.92	0.94	0.95	0.97	0.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.18	1.20	1.23	1.25	1.28	1.31
3500	0.89	0.91	0.92	0.94	0.95	0.97	0.98	1.00	1.02	1.04	1.05	1.07	1.09	1.11	1.14	1.16	1.18	1.20	1.23	1.26	1.28
4000	0.88	0.89	0.91	0.92	0.94	0.95	0.97	0.98	1.00	1.02	1.04	1.05	1.07	1.09	1.12	1.14	1.16	1.18	1.21	1.24	1.26
4500	0.86	0.88	0.89	0.90	0.92	0.93	0.95	0.97	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.19	1.21	1.24
5000	0.85	0.86	0.87	0.89	0.90	0.92	0.93	0.95	0.97	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.17	1.19	1.22
5500	0.83	0.85	0.86	0.87	0.89	0.90	0.92	0.93	0.95	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.15	1.17	1.20
6000	0.82	0.83	0.84	0.86	0.87	0.88	0.90	0.91	0.93	0.95	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.17
6500	0.80	0.81	0.83	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.95	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15
7000	0.79	0.80	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.95	0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.11	1.13
7500	0.77	0.78	0.80	0.81	0.82	0.84	0.85	0.86	0.88	0.89	0.91	0.93	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.09	1.11
8000	0.76	0.77	0.78	0.79	0.81	0.82	0.83	0.85	0.86	0.88	0.89	0.91	0.93	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.09
8500	0.74	0.75	0.76	0.78	0.79	0.80	0.82	0.83	0.84	0.86	0.87	0.89	0.91	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.07
9000	0.73	0.74	0.75	0.76	0.77	0.79	0.80	0.81	0.83	0.84	0.86	0.87	0.89	0.91	0.92	0.94	0.96	0.98	1.00	1.02	1.04
9500	0.71	0.72	0.73	0.75	0.76	0.77	0.78	0.80	0.81	0.82	0.84	0.85	0.87	0.89	0.90	0.92	0.94	0.96	0.98	1.00	1.02
10000	0.70	0.71	0.72	0.73	0.74	0.75	0.77	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.92	0.94	0.96	0.98	1.00

Meter reading to be multiplied by correction factor

These correction factors do not take into account temperature variations.

Table 1-2. Altitude Corrections (Meters)

Altitude at which Classic was calibrated (meters above sea level)	Altitude at which measurement is made (meters above sea level)																					
	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000
0	1.00	1.02	1.04	1.06	1.09	1.11	1.14	1.16	1.19	1.22	1.25	1.28	1.31	1.35	1.39	1.43	1.47	1.51	1.56	1.61	1.66
200	0.98	1.00	1.02	1.04	1.07	1.09	1.11	1.14	1.17	1.19	1.22	1.26	1.29	1.32	1.36	1.40	1.44	1.48	1.53	1.58	1.63
400	0.96	0.98	1.00	1.02	1.04	1.07	1.09	1.12	1.14	1.17	1.20	1.23	1.26	1.30	1.33	1.37	1.41	1.45	1.50	1.55	1.60
600	0.94	0.96	0.98	1.00	1.02	1.04	1.07	1.09	1.12	1.15	1.17	1.20	1.24	1.27	1.30	1.34	1.38	1.42	1.47	1.51	1.56
800	0.92	0.94	0.96	0.98	1.00	1.02	1.05	1.07	1.09	1.12	1.15	1.18	1.21	1.24	1.28	1.31	1.35	1.39	1.44	1.48	1.53
1000	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.05	1.07	1.10	1.12	1.15	1.18	1.22	1.25	1.28	1.32	1.36	1.40	1.45	1.50
1200	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.05	1.07	1.10	1.13	1.16	1.19	1.22	1.26	1.29	1.33	1.37	1.42	1.46
1400	0.86	0.88	0.90	0.92	0.93	0.96	0.98	1.00	1.02	1.05	1.07	1.10	1.13	1.16	1.19	1.23	1.26	1.30	1.34	1.39	1.43
1600	0.84	0.86	0.88	0.89	0.91	0.93	0.95	0.98	1.00	1.02	1.05	1.08	1.10	1.13	1.17	1.20	1.23	1.27	1.31	1.35	1.40
1800	0.82	0.84	0.85	0.87	0.89	0.91	0.93	0.95	0.98	1.00	1.02	1.05	1.08	1.11	1.14	1.17	1.21	1.24	1.28	1.32	1.37
2000	0.80	0.82	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.98	1.00	1.03	1.05	1.08	1.11	1.14	1.18	1.21	1.25	1.29	1.33
2200	0.78	0.80	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.98	1.00	1.03	1.05	1.08	1.11	1.15	1.18	1.22	1.26	1.30
2400	0.76	0.78	0.79	0.81	0.83	0.84	0.86	0.88	0.91	0.93	0.95	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.19	1.22	1.27
2600	0.74	0.76	0.77	0.79	0.80	0.82	0.84	0.86	0.88	0.90	0.93	0.95	0.97	1.00	1.03	1.06	1.09	1.12	1.16	1.19	1.23
2800	0.72	0.74	0.75	0.77	0.78	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.95	0.97	1.00	1.03	1.06	1.09	1.12	1.16	1.20
3000	0.70	0.72	0.73	0.75	0.76	0.78	0.80	0.81	0.83	0.85	0.88	0.90	0.92	0.95	0.97	1.00	1.03	1.06	1.09	1.13	1.17
3200	0.68	0.69	0.71	0.72	0.74	0.76	0.77	0.79	0.81	0.83	0.85	0.87	0.90	0.92	0.94	0.97	1.00	1.03	1.06	1.10	1.13
3400	0.66	0.67	0.69	0.70	0.72	0.73	0.75	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.92	0.94	0.97	1.00	1.03	1.06	1.10
3600	0.64	0.65	0.67	0.68	0.70	0.71	0.73	0.74	0.76	0.78	0.80	0.82	0.84	0.87	0.89	0.91	0.94	0.97	1.00	1.03	1.07
3800	0.62	0.63	0.65	0.66	0.67	0.69	0.71	0.72	0.74	0.76	0.78	0.80	0.82	0.84	0.86	0.89	0.91	0.94	0.97	1.00	1.03
4000	0.60	0.61	0.63	0.64	0.65	0.67	0.68	0.70	0.72	0.73	0.75	0.77	0.79	0.81	0.83	0.86	0.88	0.91	0.94	0.97	1.00

Meter reading to be multiplied by correction factor

These correction factors do not take into account temperature variations.

Section 2 - Receiving / Storage

2.1 Receiving Inspection

Upon receipt of the package:

1. Inspect the carton(s) and contents for damage. If damage is evident, file a claim with the carrier and notify the Victoreen Customer Service Department:

VICTOREEN, Inc.
6000 Cochran Rd.
Cleveland, Ohio 44139

Phone: (216) 248-9300
Fax: (216) 248-9301

2. Remove the contents from the packing material.

3. Verify that all items listed on the packing list have been received and are in good condition.

NOTE

If any of the listed items are missing or damaged, notify the Victoreen Customer Service Department.

2.2 Storage

If the unit is to be stored prior to use , pack it in the original container, if possible, and store in an environment free of corrosive materials, fluctuations in temperature and humidity, and vibration and shock. The instrument should be stored with the four 9 Volt batteries removed. Prior to use, check the condition of the desiccant. Follow the directions in section 6.1.2. A blue color means that it is OK to use, if it is pink then replace or restore.

2.3 Battery Installation / Replacement

Four 9 Volt Alkaline batteries are supplied with the Model RPO-50. The battery compartment is located inside the housing.

One to four batteries can be installed. The instrument will operate within specifications with only one battery installed. Battery life can be extended by using all four batteries.

Use the following procedure to install/replace the batteries:

CAUTION

The instrument power should be turned OFF during battery installation / replacement to prevent possible damage.

Many components on the printed circuit board are static sensitive. ESD precautions should be observed when handling the printed circuit board assembly.

The ion chamber is held at a constant -21 Volts by the permanently installed lithium batteries regardless of whether the 9 Volt batteries are installed or not. Some portions of the printed circuit board are always alive, therefore, care should be taken not to short any portion of it as permanent damage will result.

The internal ion chamber end window is very thin and fragile. After removing the instrument from the case bottom, do not lay the instrument on this window.

1. The case bottom can be detached from the case top by undoing the two external latches and gently separating the two case parts. Some resistance will be felt initially because of the seal. A quick disconnect ground wire electrically connects the cover to the case.

2. An inspection of the open instrument will reveal 4 battery holders. Align the positive and negative terminals to the holder.

CAUTION

Failure to assure proper battery polarity will result in instrument damage.

3. Slide each 9 Volt battery, terminals first, into the open end of each holder.

4. Make sure that the battery terminals are secured into their respective holder connections.

5. Carefully align the instrument top and bottom. Connect the ground wire. Insert the top into the bottom. Connect the two latches and secure.

6. Turn the instrument Function switch to the BATT position and note that the display moves into the BATT OK region to verify that the battery installation was successful.

Section 3 - Operation

3.1 Description of the Readout

Measurement results are displayed on the 200 µA, high torque, taut band, back lit, analog meter. The display includes a five decade scale and a battery OK (BATT OK) region. The scale is marked in 1/10 increments, with the 5th increment bold. The scale length is 3.5 inches (8.9 cm). The display is back lit using the Light Switch located on the top of the instrument which has three positions ON, OFF, and MOMENTARY.

To obtain the true reading, the needle position should be estimated from the scale and then the number of zeros (or decimal place) should be obtained by looking at the Function Switch position which indicates full scale value.

3.2 Description of the External Controls

3.2.1 Function Switch

The main instrument control is a 7 position rotary Function Switch - which includes the OFF position, a BATTERY check position, a ZERO position, and 4 ranges; 5, 50, 500, and 5000 mR/Hr.

OFF Position:

In the OFF position the 9 Volt alkaline batteries are disconnected from the ± 5 Volt regulators, however, the lithium battery voltage of -21 volts is still supplied to the ion chamber.

BATT Position:

In the BATT position the relative 9 Volt battery voltage can be observed on the display. While the switch is in this position, if the needle is within the BATT. OK region then the battery voltage is sufficient to operate the instrument within specifications. If the needle is outside of the BATT. OK region of the display while the function switch is in this position and steady, this indicates that the 9 Volt batteries should be replaced. To replace the batteries please see Section 2.3. Observe all safety precautions.

If the needle is outside of the BATT. OK region of the display while the function switch is in this position and slowly oscillating (1 - 2 Hz), this indicates that the lithium batteries should be replaced. To replace the batteries please see Section 6.1.1. Observe all safety precautions.

ZERO position:

In the zero position, the instrument can be adjusted so that the needle is on "0" using the guarded ZERO knob. See section 3.4.

5000 mR/Hr Position:

In this position the needle reading is multiplied by 1000. The range of the instrument is 0 to 5000 mR/Hr.

500 mR/Hr Position:

In this position the needle reading is multiplied by 100. The range of the instrument is 0 to 500 mR/Hr.

50 mR/Hr Position:

In this position the needle reading is multiplied by 10. The range of the instrument is 0 to 50 mR/Hr.

5 mR/Hr Position:

In this position the needle reading is multiplied by 1. The range of the instrument is 0 to 5 mR/Hr. The position of the needle with respect to ZERO adjustment may vary by ± .3 mR/Hr (maximum) leakage. Adjust only if necessary.

3.2.2 Zero Knob

A guarded ZERO adjustment knob is used to adjust zero on the instrument for all ranges. The instrument can be zeroed with the Function Switch in the ZERO position. A clockwise rotation will move the needle upscale, counter-clockwise downscale.

3.2.3 Light Switch

The 3 position display "LIGHT" switch, which includes an OFF position, ON position, and a MOMENTARY (spring return on) position, is used to control the back light of the display.

3.3 Beta Shield

The beta shield is a flat phenolic sheet which is thick enough to attenuate most beta rays. It is located on the bottom of the instrument and can be slid into a position covering the ion chamber or not covering the ion chamber depending upon the desired instrument response. The shield is held in each of these positions with a positive latch.

3.4 Operating the Instrument

CAUTION

Readings on the display with the function switch in the 5000 mR/Hr position indicates that the radiation rate is relatively high. These high rates can quickly cause the operator's cumulative exposure to increase with the potential for injury.

Prior to using the instrument, make sure that the calibration tag is in perfect condition and has not been tampered with. Should evidence of tampering with the calibration be seen, the instrument should NOT be used, and this fact should be reported to the appropriate personnel.

Check the battery voltage by placing the Function Switch in the BATT position and note that the display indicates in the BATT. OK region of the scale.

Rotate the Function Switch to the ZERO position. Check that the display reads "0". If not, then set it to "0" by turning the guarded ZERO knob. A clockwise rotation will move the needle upscale, counter-clockwise downscale.

Set the Function Switch to the desired range. The position selected is the full scale reading of the display. When moving the switch between ranges transient electronic noise will cause the meter needle to move up-scale giving a momentary false high reading. To minimize the time required for the display to recover to the true reading, pause at each range until the transient noise decays to a steady value, prior to moving to the next lower range position. Allow for 15 second transient decay when switching from zero to the 5 mR/Hr position.

The instrument ZERO can be checked or adjusted in any radiation field by moving the Function Switch to the ZERO position. Zero offset will be within ±.3 mR/Hr maximum during operation.

To measure high energy X-ray or gamma rays and exclude beta rays and low energy X-rays the beta shield should be closed.

To measure beta rays and low energy x-rays the beta shield should be open and the open window of the ion chamber (bottom of the instrument) should be pointed at the expected source. It should be noted that the instrument is still measuring any high energy X-rays and gamma rays present as well. The beta shield can be moved by simultaneously depressing both slide latches located midway along the bottom of both sides. With both latches depressed the beta shield will easily side in the direction of gravity.

The instrument display can be back lit, therefore, the instrument can be used in low ambient light conditions without additional external light sources. For daylight use the LIGHT Switch should be in the OFF position. In other conditions, the LIGHT Switch can be placed in the ON position. In this position the light is constantly on permitting continuous readings. This also shortens battery life. The LIGHT Switch also has a MOMENTARY position. This position is spring return to OFF. When held in the MOMENTARY position the light will be on for measurements, when released the switch will return to the OFF position, thus preserving battery life.

The center of the ion chamber is clearly marked on the top and 2 sides of the instrument.

The ion chamber is vented to the atmosphere through the desiccant system. Therefore, the ion chamber readings are sensitive to altitude. Corrections for altitude should be applied. Please see section 1.4. Normal barometric changes at a given location (altitude) will not significantly affect instrument performance.

The Model RPO-50 is not damaged by exposure to radiation rates from 5000 mR/Hr to 1000 R/Hr for 10 hours. The instrument zero should be checked and adjusted if necessary, should this occur.

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Section 4 - Theory of Operation

4.1 General

The model RPO-50 is a classic ion chamber survey meter. The ion chamber volume is approximately 349 cm^3. The ion chamber produces approximately 2.77 X 10^{-14} amperes per 1 mR/Hr. The RPO-50 can detect currents as low as 2 fA, without using reed switches or magnetic mechanical levers. To detect small signals such as 2 fA, advanced front end FET sensitive operational amplifiers are employed, along with very high resistance feedback elements. The small input signal is converted into a much larger signal which is proportionately displayed on the analog meter. A feedback network is used to select gains for different sensitivities and scales. Each scale can be independently calibrated without effecting the other scales. A Zero potentiometer is located on the instrument to null out any unwanted offsets.

The ion chamber is biased by seven lithium batteries. The bias is approximately -21 volts. A low lithium battery indicator monitors the bias voltage. If the bias voltage drops below specifications (-15 volts), then the 2 Hz oscillator is enabled during the Battery Select Check. The analog needle will oscillate at approximately 2 Hz.

4.2 Functional

An ion chamber volume of approximately 349 cm^3 in a one mR/Hr produces approximately 2.77 X 10^{-14} amperes. The ion chamber is made of phenolic with wall thickness of 0.0625 inches (0.16 cm). The window is aluminized Mylar (1 mil). The inside of the ion chamber is coated with conductive graphite. The chamber is biased at -21 volts with respect to signal ground. There is no active circuitry attached to the ion chamber assembly. The ion chamber is mounted to an ultra low noise multilayer printed circuit board. The printed circuit board has an embedded ground plane for RF shielding. The window of the meter is also protected by an optically clear RF shield. Once the ion chamber is connected to the input of the ultra low input bias current operational amplifier, radiation can be detected.

4.3 Circuit description

The small current input operational amplifier is packaged in an 8 pin DIP. The high impedance lead of the operational amplifier does not touch any surfaces with the exception of the amplifier package itself and the high impedance input circuitry. The closed loop circuit consists of a high megohm resistor, (33,000 Meg), feedback capacitor, and divider network. The seven position rotary switch (Function Switch) controls the logic functions for range changes, selected gain adjust, and shorting switch. This switch also controls the logic for the ZERO adjust and BATT functions.

Four 9 volt batteries are used to supply power to the instrument. These batteries are connected in parallel, therefore, one or all four batteries can be used. The 9 volt battery power is controlled by a p-channel FET, Q5, and is activated when the rotary switch is in any position other than OFF. The analog switch, U2, controls the shorting switch, Q4, and the Battery OK indicator. See table 4-1 below for logic.

Table 4-1. Switch Position Truth Table

Switch Position	U2, Pin 11	U2, Pin 10	U2, Pin 9
Zero	0	1	1
Batt	1	0	0
Normal Operation	0	0	0

The lithium low battery indicator is controlled by the n-channel FET, Q6. When the chamber bias voltage drops below 9 volts in magnitude, the 2 Hz oscillator, U7, is enabled.

Analog switches, U8 and U9 control the gain select and scale adjust (gain adjust) circuits. The control logic for the analog switches U8 and U9 are shown in Table 4-2.

Table 4-2. U8 and U9 Control Logic

Pin 13	Logic 1	X1	5000 mR/Hr
Pin 5	Logic 1	X10	500 mR/Hr
Pin 6	Logic 1	X100	50 mR/Hr
Pin 12	Logic 1	X1000	5 mR/Hr

The power supply is a dual ± 6 volt supply. The limiting output voltages of the operational amplifier are designed for ± 5 volts, with +5 volts representing full scale on the analog meter.

The meter is back lit by two lamps. The intensity of the lamps can be selected with a jumper located on the printed circuit board. Either the 10 volt or 5 volt lamp intensity can be selected by trained service personnel. The 5 volt option is factory selected. Please see section 6.2.3.2. Observe all safety precautions.

The printed circuit board includes easily accessible test pins, TP1 through TP11. The Table 4-3 lists the test point descriptions: (Under Normal Operation)

Table 4-3. Test Point Descriptions

Test Point	Description
TP1	HV Bias (-21 Volts)
TP2	Low Batt Ind (< 0.0 volts)
TP3	Logic Zero
TP4	Logic Zero
TP5	7 to 9 volts
TP6	-5 to -6 volts
TP7	5 to 6 volts
TP8	1 to 6 volts
TP9	equal to TP11
TP10	Zero offset
TP11	Amplifier Output

Section 5 - Calibration

5.1 Tamper Evident Adhesive Cover

The Model RPO-50 is calibrated at the factory. See Section 5.1.1 for factory calibration points. At the time of calibration, a tamper evident adhesive tag is typed upon with the calibration date and affixed to the instrument covering the 4 calibration potentiometers. Should this tag be tampered with or completely removed, it will stretch and indicate that this was the case. Also the potentiometers can not be turned under this tag without evidence of such activity being obvious. The purpose of this feature is to assure that the calibration of the instrument is not altered by unauthorized personnel. Extra calibration tags are available from Victoreen. See Appendix B for the part number.

5.1.1 Factory Calibration Points

Model RPO-50's are calibrated at the factory at one point on each range. A second test point calibration can be performed at the factory on special order. Refer to Table 5-1 for factory calibration points.

Table 5-1. Factory Calibration Points

Range	5 mR/Hr	50 mR/Hr	500 mR/Hr	5000 mR/Hr
STD CAL PT.	3.9	4.3	325	3920
2 nd. PT	1.2	13.9	110	1292

5.2 Calibration Potentiometers

The Model RPO-50 is calibrated at the factory, however, trained personnel at the user's facility may calibrate the instrument by following the procedure indicated below.

CAUTION

Readings on the display with the function switch in the 5000 mR/Hr position indicates that the radiation rate is relatively high. These high rates can quickly cause the operator's cumulative exposure to increase with the potential for injury.

The Model RPO-50 has four calibration potentiometers, one for each range of the instrument. The group of four potentiometers is marked CALIB on the top of the instrument. Each potentiometer is clearly labeled with the instrument range to which it applies; 5, 50, 500, 5000.

For the best accuracy the instrument should be calibrated near the factory calibration points identified in section 5.1.1.

The instrument should be calibrated at the nearly the same altitude (atmospheric pressure) as its intended use.

1. Remove the previous calibration tag.

2. Verify that the battery voltage is OK placing the Function Switch in the BATT position and note that the display indicates in the BATT. OK region of the scale.

3. Zero the display by rotating the Function Switch to the ZERO position. Check that the display reads "0". If it does not read "0", then set it to "0" by turning the guarded ZERO knob. A clockwise rotation will move the needle upscale, counter-clockwise downscale.

4. Set the Function Switch to the desired range. The position selected is the full scale reading of the display. When moving the switch between ranges transient electronic noise will cause the meter needle to move up-scale giving a momentary false high reading. To minimize the time required for the display to recover to the true reading, pause at each range until the transient noise decays to a steady value, prior to moving to the next lower range position. Because all ranges are independent, it does not matter in which order they are calibrated.

5. Place the entire instrument in the radiation source field. Observe the center of the chamber markings on the instrument when positioning the instrument.

6. Turn the calibration potentiometer associated with the range selected to obtain the correct display indication. A clockwise potentiometer rotation will move the needle upscale, counter-clockwise downscale.

7. Repeat steps 4 through 6 for all ranges.

8. Type a new calibration tag with the date of calibration and affix over the entire 4 potentiometers.

Section 6 - Maintenance / Troubleshooting

6.1 Preventive Maintenance

6.1.1 Batteries

To replace the 9 Volt batteries please see Section 2.3. Observe all safety precautions.

To replace the lithium batteries see section 6.2.2.4.

6.1.2 Desiccant

Approximately 1 oz. (28 grams) of silica gel desiccant in a clear plastic container are supplied inside the Model RPO-50. This desiccant is blue or dark blue if ready for use. If the desiccant is pink or clear (wet), it requires replacement or drying.

The container is located on the battery assembly. Use the following procedure to check, restore or replace the desiccant:

CAUTION

The instrument power should be turned OFF during desiccant inspection or replacement to prevent possible damage.

Many components on the printed circuit board are static sensitive. ESD precautions should be observed when handling these components.

The ion chamber is held at a constant -21 volts by the permanently installed lithium batteries regardless of whether the 9 Volt batteries are installed or not. Some portions of the printed circuit board are always alive, therefore, care should be taken not to short any portion of it as permanent damage will result.

The internal ion chamber end window is very thin and fragile. After removing the instrument from the case bottom, do not lay the instrument on this window.

1. The case bottom can be detached from the case top by undoing the two external latches and gently separating the two case parts. Some resistance will be felt initially because of the seal. A quick disconnect ground wire electrically connects the cover to the case.

2. A visual inspection will show that the desiccant is located in a clear plastic container on the battery assembly. Note the color and proceed accordingly. The container has an easily removable lid. Remove the container from the assembly and disconnect the plastic tube. The desiccant can be replaced if necessary by fresh desiccant or itself dried. The desiccant can be dried and restored by heating overnight (12 hours or until the desiccant turns blue) at 50°C.

3. Carefully align the instrument top and bottom. Connect the ground wire. Insert the top into the bottom. Connect the two latches and secure.

4. Turn the instrument Function switch to the BATT position and note that the display moves into the BATT OK region to verify that the instrument is performing. Use a check source if possible to verify proper operation.

6.2 Corrective Maintenance

6.2.1 Precautions

CAUTION

The instrument power should be turned OFF any time that the instrument is opened to prevent possible damage.

Many components on the printed circuit board are static sensitive. ESD precautions should be observed when handling the printed circuit board assembly.

The ion chamber is held at a constant -21 Volts by the permanently installed lithium batteries regardless of whether the 9 Volt batteries are installed or not. Some portions of the printed circuit board are always alive, therefore, care should be taken not to short any portion of it as permanent damage may result.

The internal ion chamber end window is very thin and fragile. After removing the instrument from the case bottom, do not lay the instrument on this window.

6.2.2 Disassembly

The case bottom can be detached from the case top by undoing the two external latches and gently separating the two case parts. Some resistance will be felt initially because of the seal.

Disconnect the ground wire.

6.2.2.1 External End Window Replacement

Remove ion chamber cover by loosening two screws and the HV bias nut. Gently slide the chamber cover off. Remove damaged window with a razor blade. Clean surface of the rim. Apply glue (photo mount) to rim only. Attach with mylar conductive side in. Allow to dry and trim mylar.

6.2.2.2 Internal End Window Replacement

Remove four small rubber feet on the bottom of the case. Lift off the beta shield guide assembly. Remove damaged window with razor blade. Sand surface clean. Apply dry mount glue to surface. Attach with mylar conductive side out. DAGG over small area to cover some mylar and the exposed metal on the cable.

6.2.2.3 Light Intensity Adjustment

Switch jumper arrangement on PCB from 5V to 10V. Lamp is industry standard 7218 bulb.

6.2.2.4 Lithium Battery Replacement

Measure each lithium cell B1 - B7. Each cell should exceed 1.5V. If not, remove that cell from the PCB and replace with a new cell.

6.2.2.5 Circuit Troubleshooting

If the RPO-50 does not zero properly or display correctly for the proper ranges, perform the following functional test. Remove the meter from the bottom case assembly. The battery voltage should be between 6.4 volts and 9.4 volts. Inspect for loose parts or connectors. Examine solder joints on the rotary switch assembly.

1. Place the rotary switch to the OFF position.

2. Check the following test points:
   TP5 for 0.0 Volt ±0.5V
   TP6 for 0.0 Volt ±0.5V
   TP7 for 0.0 Volt ±0.5V
   J3-1 for 0.0 Volt ±0.5V
   If voltages are correct continue to step 3. If voltages are incorrect replace U6 and Q5 as necessary.

3. Check TP1 (lithium batteries) for -10V to -21V. Replace lithium cells if necessary.

4. Check TP4 for LOGIC "0". If LOGIC 0 exists continue to step 5. If not replace Q6.

5. Place the rotary switch to the BATT position.

6. Check the following test points:
   TP4 for LOGIC "1".If LOGIC 0, check U7, Pin11. Replace U7 if necessary.
   TP5 for 9.0 Volt battery power. Replace battery U6 or Q5 as necessary.
   TP6 for -6.0 Volts ±0.5V. Replace U5 if necessary.
   TP7 for 6.0 Volts ±0.5V. Replace U3 if necessary.
   If U3 and U5 had been replaced and voltages still fail, replace U4.

7. Check TP8 for 6 Volts ± 0.5V. If voltage is incorrect check LOGIC on U2 and Q4. (See Table 4-1).

8. Check SW1 pin: C3 for LOGIC "0" This checks the operation of U7, Q6 and RN1.
   (Rotary switch) C4 for LOGIC "0" This checks the operation of RN1 and D5.
   C5 for LOGIC "0" This checks the operation of RN1 and D5.
   C6 for LOGIC "0" This checks the operation of RN1 and D5.
   C7 for LOGIC "0" This checks the operation of RN1 and D5.

9. Place the rotary switch to the ZERO position.

10. Check SW1 pin: C3 for LOGIC "1" This checks the rotary switch.
    (Rotary switch) C4 for LOGIC "0" This checks the operation of RN1.
    C5 for LOGIC "0" This checks the operation of RN1.
    C6 for LOGIC "0" This checks the operation of RN1.
    C7 for LOGIC "1" This checks the operation of D5.
    TP4 for LOGIC "0" This checks the operation of U7 and Q6.
    Q4-G for -6 Volts ±0.5V This checks the operation of U2.

11. Check the offset voltage at TP11 by performing the following:
    Vary the ZERO potentiometer to see if the offset changes. Vary RP1 to see if offset changes. If the zeroed position on the meter does not agree with the zeroed position when the rotary switch is placed to the 5mR/Hr range (±500µR/Hr), replace Q4. If this does not correct the offset, replace U1. If the meter can not be zeroed correctly after performing the previous steps, the ion chamber may need replacement. Please contact VICTOREEN.

NOTE
TP12 is the junction of C1 and R29 on the main PC Board.

12. Check the impedance from Q4-D to TP12 or R29 junction. Impedance should be less then 200 ohms while in the ZERO position. Replace U2 if necessary.

13. Place the rotary switch to the 5000 mR/Hr position and Check:
    TP12 for 5.0 Volts ±1V
    J1-5 for 5.0 Volts ±1V
    If voltages are out of tolerance, check connectors and replace U8 and U9 if necessary.

14. Place the rotary switch to the 500 mR/Hr position and Check:
    TP12 for 0.5 Volts ±0.1V
    J1-4 for 5.0 Volts ±1V
    If voltages are out of tolerance, check connectors and replace U8 and U9 if necessary.

15. Place the rotary switch to the 50 mR/Hr position and Check:
    TP12 for 0.05 Volts ±0.01V
    J1-3 for 5.0 Volts ±1V
    If voltages are out of tolerance, check connectors and replace U8 and U9 if necessary.

16. Place the rotary switch to the 5 mR/Hr position and Check:
    TP12 for 0.005 Volts ±0.001V
    J1-5 for 5.0 Volts ±1V
    If voltages are out of tolerance, check connectors and replace U8 and U9 if necessary.

6.2.3 Reassembly

1. Carefully align the instrument top and bottom. Connect the ground wire. Insert the top into the bottom. Connect the two latches and secure.

2. Turn the instrument Function Switch to the BATT position and note that the display moves into the BATT OK region to verify that the instrument is operating.

NOTE
Allow 15 seconds for settling time, after performing step 3.

3. Turn the instrument Function Switch to the ZERO position and note that the instrument zeros. Use the ZERO knob if necessary.

4. Use a check source if possible to verify proper operation.

5. Any time that the RPO-50 is disassembled for anything other than routing preventive maintenance, it should be recalibrated.

Appendix A - Customer Replaceable Parts

Part Number	Description
181004	Cover Assembly/Meter
181003	Case Assembly
109-172	Rubber Feet (large)
109-171	Rubber Feet (small)
181040	Catch Spring
181052	Gasket U-Channel
181051	Meter
181041	Zero Guard
11-295	Toggle Switch
181056	7 Position Rotary Switch
181020	Gain Assembly
181017	Desiccant Assembly
181015	Battery Assembly
181008	Ion Chamber
181018	Main PCB Assembly/Chamber
46-122	O-Ring
181010	Main PCB Assembly
17-92	Lamps
63-193	U1, Operational Amplifier
185-4091	33000 MEG Resistor
181047	EMI Shield
22-368	Zero Potentiometer
181001	Manual

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Appendix B - RPO-50 Technical Paper

This appendix contains the technical paper " **A New Improved Classic Ion Chamber Survey Meter**" by C. W. King and J. D. Shearer of Victoreen. If addition copies of this paper are needed, please contact Victoreen.

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A New Improved Classic Ion Chamber Survey Meter

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ABSTRACT

A new improved ion chamber survey meter based upon classic analog design principles and advanced FET circuits has been developed. The ion chamber has a 349 cm^3 volume with a thin mylar™ entrance window and removable 493 mg/cm^2 beta shield. The instrument measures betas, X-rays, and gamma rays. The survey meter is an all metal construction and has been found to meet ANSI N42.17A (Ref. 1) performance criteria for use in normal environment conditions, and ANSI N42.17C (Ref. 2) performance criteria for use in extreme environmental conditions. The survey meter is classically designed, with a handle, analog display meter, seven position function knob, guarded zero knob, and four separate calibration potentiometers. The calibration potentiometers are flush to the instrument surface and secured by a tamper evident calibration seal. The total dynamic range of 0 to 5000 mR / hr is covered by four selectable ranges. The instrument is designed to be resistant to the infusion of noble gases and suitable for use in nuclear facilities.

The sensitivity of the instrument to beta rays was found to range from 76.1 mR / hr / μCi for $^{90}Sr/^{90}Y$ to 5.1 mR / hr / μCi for ^{14}C. The collection efficiency for gamma rays was determined to be 94 % minimum, under worst case conditions. The linearity was found to vary less than 1% over the entire range of the instrument. Also presented is the energy response to X-rays and gamma rays, which was determined for two orthogonal directions, with the beta shield in the open and closed positions. Test results from ANSI N42.17C performance categories are presented. This new ion chamber survey meter is compared to other traditional survey meters. The instrument's ruggedness and durability make it suitable for a variety of health physics applications.

INTRODUCTION

The classic ion chamber survey meter described herein has been designated the RPO-50. This paper describes this ruggedized survey instrument, provides the theory of operation, and presents the methodology and results for all ANSI N42.17C tests conducted. Comparisons are made to the features of other traditional ion chamber survey meters.

GENERAL DESCRIPTION

The Model RPO-50 is a portable, battery operated general purpose ion chamber survey meter. The design combines surface mount analog circuit technology, advanced "front end" FET sensitivity, and rugged mechanical features in an easy to use instrument. The instrument is housed in a heavy duty aluminum case with an ergonomically designed cast aluminum handle.

Measurement results are displayed on a high torque, back lit analog meter. The display includes a five decade scale and a battery OK region.

The following controls are available on the instrument:

A seven position rotary Function Switch - which includes the OFF position, a BATTery check position, a ZERO position, and four ranges; 5, 50, 500, and 5000 mR/hr.

A three position display light switch - which includes an OFF position, ON position, and a spring return (MOMENTARY) on position.

A guarded ZERO adjustment knob - which is used to adjust zero on the instrument for each range.

Four 9 Volt alkaline batteries are mounted in rugged battery holders on their own circuit board inside the case. The battery lifetime is greater than 3000 hours. The manual battery check verifies that sufficient voltage is available to operate the instrument. The ion chamber is biased at -21 volts by seven lithium batteries soldered onto the main printed circuit board. The lithium batteries have a lifetime of greater than 10 years in this application.

The ion chamber is 21.3 in^3 (349 cm^3) in volume which provides for excellent minimum detectability and stability for X-rays and gamma rays. The ion chamber thin end window, which is 3.25 inches (8.255 cm) in diameter, is positioned very close to the external instrument thin end window. The instrument's rubber feet have a 0.25 inch (0.6 cm) length. All of these features are designed for an optimal minimum detectability and sensitivity for beta rays. The 495 mg/cm^2 beta shield has a positive locking system for the open and closed positions, and is very easy to move.

The survey meter contains desiccant located inside the housing in a plastic container and indicates by its color whether it is wet (pink) or dry (blue). The desiccant container has a lid for ease of desiccant replacement and / or drying. The desiccant can be restored by heating overnight at 50°C. The ion chamber is vented through the desiccant system by a sealed plastic tube.

The instrument features four easily accessible calibration potentiometers, one for each range. A tamper evident calibration adhesive tag covers the four calibration potentiometers.

There are no open holes in the case and gaskets are incorporated into the mating surfaces of all external parts. Thus the instrument is sealed and is resistant to dirt, moisture, contamination, and radioactive gas infusion.

Other than the controls, there are no moving parts, such as magnetic reed switches or mechanical arms. This assures mechanical ruggedness and the highest reliability available.

THEORY OF OPERATION

The survey instrument employs a 349 cm^3 ion chamber to detect radiation. The ion chamber produces approximately 2.77×10^{-14} amperes per 1 mR/hr exposure. The instrument can detect currents as low as 2 femtoampreres (fA) without using reed switches or magnetic

mechanical levers. To detect small signals such as 2 fA, advanced front end FET sensitive operational amplifiers are employed along with very high resistance feedback resistance elements. The small input signal is converted into a much larger signal which is proportionately displayed on the analog meter. A feedback network is used to select gains for different sensitivities and scales. Each scale can be independently calibrated without affecting the other scales. A zero potentiometer is located on the instrument to null out any unwanted offsets.

The ion chamber is biased by seven lithium batteries having a ten year lifetime. The bias is approximately 21 volts which gives collection efficiency of greater than 94% under all conditions. A low battery indicator for the lithium cells monitors bias voltage. If the bias voltage drops below specifications, a 2 Hz oscillator is enabled during battery check.

The methodology and results for all ANSI N42.17C tests conducted are presented in the following sections.

BATTERY POWER

The battery power requirement (Sec. 4.4, Ref. 1) states that the battery shall provide a minimum operating period of 4 to 10 hours.

The battery lifetime of the RPO-50 using four 9 Volt alkaline batteries is measured to be greater than 3000 hours.

BATTERY POWER INDICATOR

The battery power indicator requirement (Sec. 4.5, Ref. 1) states that the instrument shall be within 10% of the reference reading when the instrument first shows battery failure.

The battery voltage was replaced by a DC power supply. The voltage was then lowered until failure was indicated. The displayed reading showed no detectable difference from the reference.

STABILITY

Drift is defined (Sec. 2, Ref. 1) as the change in readout, usually gradual without concomitant change in the influence quantity. The stability requirement (Sec. 5.2, Ref. 1) states that drift under constant conditions of temperature and pressure shall be within 6% of the initial mean over a two hour period.

Measured results on three instruments over a two hour period indicate a 0.075 mR / hr drift when the instruments are exposed to a gamma radiation field of 2.5 mR / hr. These measurements represent a 1.5% per hour drift.

WARM UP AND RESPONSE TIME

The instrument is fully functional within 15 seconds upon power on, thus meeting the warm up requirement (Table 1, Ref. 1) of less than 10 minutes.

The response time is measured by recording the time from 10% to 90% of the established equilibrium reading (Sec. 5.3, Table 3, Ref. 1). The maximum permissible response time is 30 seconds. Measured response time on 3 instruments is typically 2.5 seconds at room temperature. Response time at -40°C and 70°C is also within specifications. An actual response curve at room temperature is shown in Figure 1.

ACCURACY, PRECISION

The accuracy of the instrument (Sec. 6.1, Ref. 1) must be stated and the requirement is defined to be within 20% at extreme conditions. The accuracy was measured on three instruments at extreme temperature and humidity conditions (with permitted air density corrections) and was found to be within 6% full scale, thus meeting the accuracy requirements.

The precision was calculated on twenty readings from one instrument. Readings were taken at an interval of 5 time constants. The mean and standard deviation of twenty readings were calculated to be 3.485 and 0.027 respectively. This yields a coefficient of

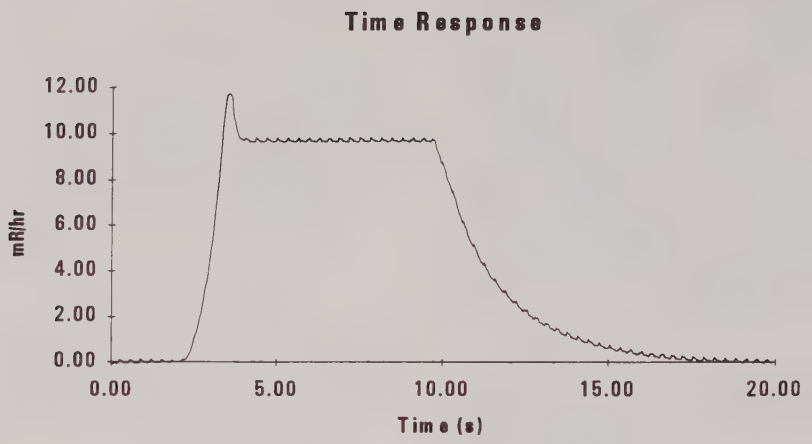

Figure 1

variation of 0.7%, thus meeting the requirement (Sec. 6.1, Ref. 1) for accuracy and precision.

ENERGY DEPENDENCE

Figure 2 shows the instrument photon energy response as a function of instrument orientation with respect to the radioactive source and beta shield position.

Figure 3 shows the instrument beta ray energy response with the beta window open.

HIGH ENERGY PHOTONS

The response of the instrument (Sec. 6.2, Ref. 1) to ^{60}Co photons as a ratio of the ^{137}Cs response is shown in Figure 2.

ELECTROMAGNETIC

The electromagnetic interference requirement (Sec. 7.1, Ref. 1) states that the instrument should show less than 15% variation when positioned in a radio frequency or microwave field. The instrument's response was within the 1.5% per hour drift while exposed to radio frequency fields of 400 V/meter at the frequency or within the range of 60 Hz, 500-2000 kHz, and 140 MHz. The instrument's response was within the 1.5% per hour drift while exposed to a microwave field of 200 W / m^2 at the microwave frequency for all

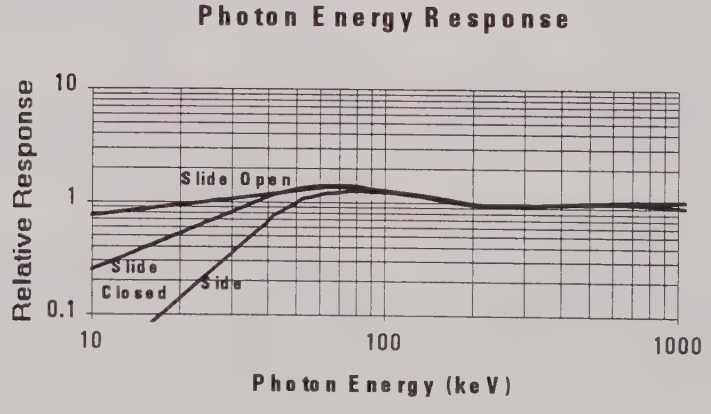

Figure 2

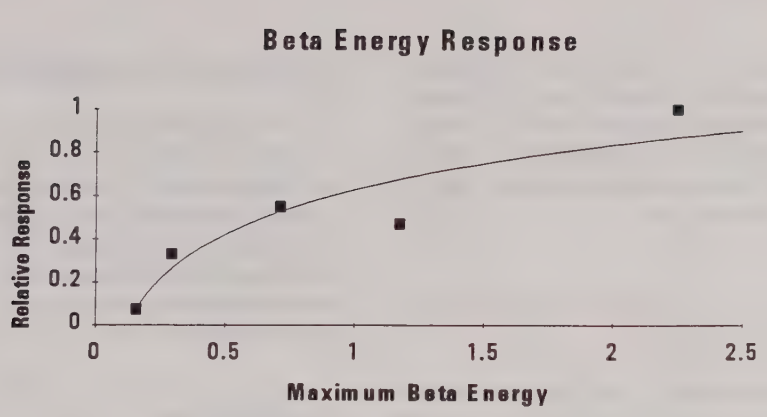

Figure 3

orientations except directly through the thin entrance window which exceeded the 15% limit.

TEMPERATURE

The temperature requirement (Sec. 8.1, Ref. 1) states that the instrument display readings shall be within 20% of the mean at 22°C over the temperature range of -40°C to 70°C. Corrections to the instrument's readings for air density changes are permitted and were incorporated.

Measured results on 3 instruments were all within 5%. See Figure 4 for the temperature dependence graphs of the three instruments tested.

EXTREME TEMPERATURE SHOCK (METHOD 1)

The extreme temperature shock requirement (Sec. 8.2, Ref. 1) states that the mean instrument response not vary more than 15% from a set of reference readings taken at 22°C when the instrument is cycled between -40°C and 70°C in less than 5 minutes.

The actual observed variation in pre- and post- exposure readings on three instruments was not detectable.

HUMIDITY AND TEMPERATURE

The humidity and temperature requirement (Sec. 8.4, Ref. 1) states the mean

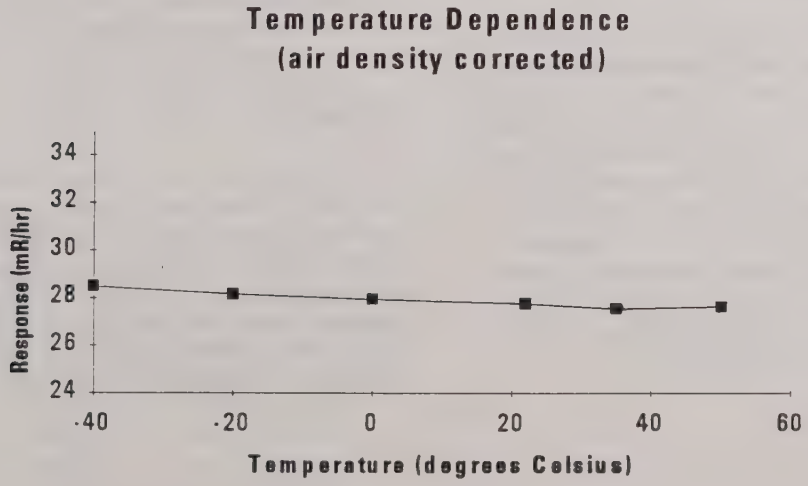

Figure 4

instrument response shall not vary more than 15% over the relative humidity range of 3% to 95% non-condensing referenced to 60°C. The instrument's response was within 5% of the initial reading during the entire time that it was exposed to these conditions.

MECHANICAL SHOCK

The mechanical shock requirement (Sec. 8.5, Ref. 1) states that the instrument response shall vary less than 15% from a set of reference readings following mechanical shocks from all directions with magnitude up to 100G. The instrument tested showed no detectable change in reference readings.

VIBRATION

The vibration requirement (Sec. 8.6, Ref. 1) states that the instrument response shall vary less than 15% from a set of reference readings following extended 15 minute harmonic loadings of 3.5G applied in each of the 3 mutually orthogonal axes in the frequency range of 15 to 200 Hz. The instrument tested, the same unit used in the shock test, showed no detectable change in reference readings.

AMBIENT PRESSURE

The ambient pressure requirement (Sec. 8.7, Ref. 1) states that the instrument response shall vary less than 15% from the mean instrument response at 101 kPa over a pressure range of 55 to 150 kPa. Correction to the instrument readings for air density changes are permitted. Because correction constants to the instrument for air density (atmospheric pressure) were originally determined so that there would be no variation in the instrument response, this is a null experiment. The instrument meets this requirement.

CONDENSING ATMOSPHERES

The condensing atmospheres requirement (Sec. 8.8, Ref. 1) states that the instrument response shall vary less than 15% during and following exposure to condensing environments over a period of 8 hours. Four instruments were evaluated with an average variation of 4.2% over the 8 hour period. The maximum variation was 6.5%.

DURABILITY

The requirement of the durability test (Sec. 8.9, Ref. 1) states that the instrument response shall vary less than 15% with a 95% confidence level following 5 cycles of accelerated aging. This test takes four days and includes humidity, temperature, and vibration with peak acceleration of 50Gs. Three instruments were evaluated with the maximum variation being less than 6%.

RADIATION RESISTANCE

The radiation resistance requirement (Sec 8.10, Ref. 1) states that the instrument response shall vary less than 15% after exposure to 10^4 rads. The instrument meets this requirement. No detectable change was observed in instrument response at normal exposures. The only adjustment necessary was to re-zero the instrument due to a slight radiation induced offset, as is recommended in the manual after these conditions.

DROP TEST

The requirement of the drop test (Sec. 8.11, Ref. 1) states that the instrument shall continue to operate after a fall of 1 meter onto a concrete surface. The instrument response shall vary less than 15% after a series of 5 drops. The instrument tested, the same unit used in the shock and vibration tests, showed a maximum variation of 7% from the reference reading.

MOISTURE EXPOSURE

The moisture exposure (rain) requirement (Sec. 8.12, Ref. 1) states that the instrument response shall vary by less than 15% following exposure to lightly falling rain (1/4 inch per hour) for a period of 2 hours at 20°C. The instrument's response was within the 1.5% per hour drift while exposed to a measured rain of 1/2 inch per hour.

The moisture exposure (fog) requirement (Sec. 8.13, Ref. 1) states that the instrument response shall vary by less than 15% following exposure to fog for a period of 6 hours at 22°C. The instrument's response was within 3% of the initial reading during the entire time that it was exposed to these conditions.

This concludes the sections dedicated to the methodology and results for all ANSI N42.17C tests conducted. See Appendix A for a summary of test results.

COMPARISONS

Table 1 compares the features of the RPO-50 to various traditional ion chamber survey meters.

As can be seen from the comparison table, the features of the RPO-50 compare favorably with traditional ion chamber survey meters. The larger ion chamber volume, and the larger surface area of the ion chamber entrance window, enhances stability and sensitivity to beta rays and photons, at low exposure rates. Other features mean improved mechanical ruggedness, improved maintenance, and improved operations.

CONCLUSIONS

The RPO-50 follows the traditional analog ion chamber survey meter design. It meets all ANSI N42.17A performance criteria for use in normal environment conditions, and all ANSI N42.17C performance criteria for use in extreme environmental conditions, thus demonstrating suitability for health physics applications where ruggedness and durability are required. The only exception to the specifications is that the instrument response will vary by more than 15% when microwaves are beamed directly through the thin entrance window. The features of the RPO-50 compare favorably to other traditional ion chamber survey meters.

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REFERENCES

1. American National Standard Performance Specifications for Health Physics Instrumentation - Portable Instrumentation for Use in Extreme Environmental Conditions. New York: Institute of Electrical and Electronic Engineers; ANSI N42.17C-1989; 1990

2. American National Standard Performance Specifications for Health Physics Instrumentation - Portable Instrumentation for Use in Normal Environmental Conditions. New York: Institute of Electrical and Electronic Engineers; ANSI N42.17A-1989; 1989

FEATURE	RPO-50	Type X1	Type X2	Type Y
Chamber Volume (cm^3)	349	208	220	200
Moving mechanical parts	None	Arm	Relay	Arm
Sealed against noble gas	Yes	No	No	No
Tamper evident calibration	Yes	No	No	No
Identical controls/display	Yes	Yes	No, 50R/hr range	Yes
Window area (cm^2)	53.5	37.5	41	41
Easy to maintain (mylar replacement, front end accessibility)	Yes	No	No	No
Weight (lbs)	3.3	3.8	3.6	3.1
Battery Type	9V	9V	"C"	9V
Number of Batteries	1 to 4	3	5	1
Battery life (hours)	3000	330	350-6900	200

Table 1. Comparison Among Commercially Available Ion Chamber Survey Meters

APPENDIX A

SUMMARY of ANSI N42.17C TEST RESULTS for the RPO-50

ANSI N42.17C Test Name	Acceptance Criteria	RPO-50 Test Results
Battery power	> 10 hours	3000hours
Battery power Indicator	< 10%	No change
Stability	< 3% / hour	1.5% / hour
Warmup	< 10 minutes	15 seconds
Response time	< 30 seconds	2.5 seconds
Accuracy	< 20 %	< 6%
Precision		0.7%
Energy Dependence	Stated	See Figure 2
High Energy Photons	Stated	See Figure 2
Electromagnetic	< 15%	< 1.5%[1]
Temperature	< 20%	< 5%
Extreme Temperature Shock	< 15%	< 1.5%
Humidity and Temperature	< 15%	< 6%
Mechanical Shock	< 15%	No change
Vibration	< 15%	No change
Ambient Pressure	< 15%	Stated
Condensing Atmosphere	< 15%	< 6.5%
Durability	< 15%	< 6%
Radiation Resistance	< 15%	No change[2]
Drop Test	< 15%	< 7%
Moisture Exposure	< 15%	< 1.5%
Fog	< 15%	< 3%

Notes:

1. The instrument's response was within the 1.5% per hour drift while exposed all radio frequency fields and to a microwave field of 200 W / m^2 at the microwave frequency for all orientations except directly through the thin entrance window which exceeded the 15% limit.

2. The only adjustment necessary was to re-zero the instrument due to a slight radiation induced offset, as is recommended in the manual after these conditions.

VICTOREEN MATERIAL RETURN FORM

NAME OF SENDER _____

PHONE NUMBER _____

COMPANY AFFILIATION _____

STREET _____

CITY _____ STATE _____ ZIP _____

CUSTOMER ORDER NUMBER _____

VICTOREEN REGISTER NUMBER OR INVOICE NUMBER _____

DATE PURCHASED _____

MODEL NUMBER _____ SERIAL NUMBER _____

WARRANTY REPAIR YES _____ NO _____

REASON FOR RETURN _____

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MA32734

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